1961

REPORT

ON THE

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arm and other Experiment Stations

IN THE

ROVINCES OF AGRA AND OUDH

HE YEAR ENDING ON JUNE 30TH, 1902. 5 1905-06

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of the N.P. of Agra & Oudh, report
1906-07 to 1909-10
(b Partabgarh Agricultural Station, 1908-09, 190
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Report on the Cawnpore Experimental Farm and other Experiment Stations for the year 1901-1902.

CHAPTER I.

Field experiments conducted at the Cawnpore Farm.

1.—HISTORY, &c.

The farm is situated in the village of Gotaiya, about three miles from Cawnpore ; it is within a few yards of the Rawatpur station on the Cawnpore-Achnera Railway, and at a distance of about four miles from the East Indian Railway and five miles from the Oudh and Rohilkhand Railway station. The land occupied was originally rented from the land-holders and tenants of Gotaiya in 1881 and in that year the important manurial experiments still carried on in the "standard" and "duplicate" series, which will be described presently, were started by Mr. J. B. Fuller, then Assistant Director of this Department. The tenure of the land remained unaltered until the present year; changes in the tenancy law of the province had however rendered our tenure illegal in the case of several fields, and the ownership of the whole area has now been acquired by Government.

During the early years of management the area of the farm underwent frequent changes, but of late it has not varied, and is 51·33 acres in extent, of which 36·34 acres are under cultivation and the rest is occupied with roads, water-courses and farm buildings. Of the cultivated area about six acres consist of small corner plots or irregular fields, unsuitable for experimental work, and this area is utilized for raising fodder for the farm cattle. The whole area of the farm is irrigable from a distributary of the Ganges canal, and is thus well protected against seasons of drought or deficient rainfall.

The soil of the farm may be accepted as a fair sample of the light reddish alluvial loam which occurs over a large portion of the Ganges-Jumna Doab. Though according to the analyses made in 1882 by the late Mr. S. A. Hill, B.Sc., it contains 78·56 per cent. of insoluble sand, yet owing to the fineness of the particles its physical characters are those of a clayey loam. The soils of a good many plots of the farm have been analysed by the Agricultural Chemist to the Government of India, and the following table gives the composition of five unmanured plots as regards the three dominant agricultural ingredients (*vide* page 54, Agricultural Ledger No. 2 of 1898).

Composition of the soils of the unmanured plots of the Farm.

Name of plot.	Total nitrogen.	Total phosphoric acid.	Available phosphoric acid.	Available potash.
	Per cent.	Per cent.	Per cent.	Per cent.
Rabi standard, No. 11 ...	·024	·085	·021	·012
Kharif standard, No. 13 ...	·016	·053	·022	·007
Alternate series A, No. 13 ...	·017	·088	·030	·007
Alternate series B, No. 11 ...	·023	·071	·014	·012
Green manure series, No. 5 ...	·017	·053	·015	·027
Avergae	·019	·070	·020	·013

Chemical analyses and practical experience concur in showing that there is no abnormal deficiency of lime or any other plant-food ingredients.

2.—CHARACTER OF THE SEASON.

Vide Appendix I.

The season was on the whole favourable. The total rainfall was 27·03 inches, but it was well distributed from July onwards. Light showers began on July 9th, and there was sufficient rain till the end of August. A long break in September caused some anxiety but a heavy fall on the 24th of that month secured the kharíf and facilitated tillage for the rabi. The cold weather was very dry and, as usual, some damage from rats and whiteants ensued. The rabi harvest was about a week earlier than usual. *

3.—MANURIAL EXPERIMENTS.

The following manurial experiments were carried on during the past year :—

Name.	Crop.	Number of plots.	Area in acres.	Duration of experiments.
1. Kharíf standard ...	Maize (every year) ...	13	1·07	Permanent.
2. Rabi standard ...	Wheat (ditto) ...	13	1·07	Ditto.
3. Duplicate or alternate series A.	Maize and wheat alternately.	13	1·07	Ditto.
4. Ditto B ...	Ditto ...	13	1·07	Ditto.
5. Green manuring series.	Wheat ...	10	1·25	Under alteration.
6. Rotation with leguminosæ.	Do. ...	7	0·58	
7. Sugarcane series ...	Sugurcane ...	20	5·50	So long as the Agricultural Chemist desire.
8. Potato series ...	Potato ...	10	1·00	Until 1903.
	Total ...	99	12·61	

Maize and wheat.—The first four experiments are carried on in four series of 13 plots each, *i.e.*, on 52 plots in all. When originally started in 1881 by Mr. J. B. Fuller there were only ten plots in each series, and the remaining three plots were subsequently added in 1882 and 1883. Since then there has been no change in the number of plots. One series is cropped every year with maize, another with wheat, and these two are called kharíf and rabí standard series respectively. In the other two series known as " alternate series " maize and wheat are grown in rotation in alternate years. Thus the maize crops on the kharíf standard plots get every year a fallow of about nine months, while those on the duplicate plots, a fallow of only about two months after the previous crops of wheat is cut. But as regards wheat the rabi standard plots get a fallow of six months against the 13 months on the duplicate plots. Owing to this reason the maize on the standard plots is, as a rule, better than on the duplicate plots, while the wheat on the alternate plots is better, though the difference is less marked and less certain than is the case with maize. The manure applied to one plot of the standard series is also applied to the corresponding plot of the duplicate series. The object of the kharíf and rabi standard series is to ascertain the effects and establish the relative values of certain manures on maize and wheat grown year after year on the same land. The object of the alternate series is to some extent to duplicate these trials and also to study the effects and economy of alternation of maize with wheat.

The scheme of treatment of these plots was changed three years ago at the instance of the Agricultural Chemist to the Government of India. The old and new schemes, as well as the compositions and quantities of manures applied during the year under report, are given in the next table.

* Appendix II (temperature) is not printed this year as the records are very incomplete owing to accidents with the thermometers.

Table showing the old and new schemes of treatment and compositions and quantities of manures.

Rabi standard.	Alternate B.	Kharíf standard.	Alternate A.	Old treatment.	New treatment.	Composition and quantities of manures applied per acre in 1901-1902. Maize. Percentage of nitrogen.	Maize. Quantity of manure applied.	Wheat. Percentage of nitrogen.	Wheat. Quantity of manure applied.	Remarks.
							lbs.		lbs.	
R.3	3	K.3	6	Cattle manure @ 180 mds. per acre ...	Cattle manure to supply 100 lbs. Nitrogen per acre	·81	12,346	·37	27,027	
R.4	4	K.1	7	Cattle manure and bonedust @ 4½ mds. per acre ...	Cattle manure to supply 50 lbs. Nitrogen per acre.	·81	6,173	·37	13,513	
R.5	5	K.2	8	Cattle manure and gypsum @ 3 mds. per acre ...	No manure ...	...	...	...	...	
R.6	6	K.10	1	Sheep-dung @ 180 mds. per acre ...	Sheep-dung to supply 100 lbs. Nitrogen per acre	1·70	5,882	·70	14,286	
R.8	8	K.7	10	Sheep-dung and bonedust @ 4½ mds. per acre ...	Sheep-dung to supply 50 lbs. Nitrogen per acre	1·70	2,941	·70	7,143	
R.10	10	K.12	12	Sheep-dung and gypsum @ 3 mds. per acre ...	Poudrette to supply 50 lbs. Nitrogen per acre	·37	13,513	·41	12,195	
R.12	12	K.9	2	Poudrette @ 180 mds. per acre ...	Poudrette to supply 100 lbs. Nitrogen per acre	·37	27,027	·41	24,390	
R.1	1	K.5	4	Saltpetre @ 3 mds. per acre ...	Saltpetre to supply 25 lbs. Nitrogen per acre	12·62	198	12·62 13·3	193	
R.2	2	K.11	5	Saltpetre and bonedust @ 4½ mds. per acre ...	Saltpetre to supply 25 lbs. Nitrogen per acre. (35 lbs. Nitrogen per acre.)	12·62	198	12·62 13·3	193	
					Bonedust to supply 10 lbs. Nitrogen per acre.	2·33	429	3·13	319	
R.9	9	K.6	11	Saltpetre and bone-superphosphate ... each @ 3 mds. per acre ...	Saltpetre to supply 25 lbs. (35 lbs. Nitrogen per acre.)	12·62	198	12·62 13·3	193	
					Bone-superphosphate. 10 lbs.	2·36	423	2·36	423	
R.7	7	K.4	9	Ashes of 180 mds. of cow-dung per acre ...	Ashes of 180 mds. of cow-dung per acre ...	·02	5,445	·04	5,590	
R.13	13	K.8	3	Ashes and saltpetre @ 3 mds. per acre.	Ashes and saltpetre to supply 25 lbs. Nitrogen per acre ...	·02	5,445	·04	5,590	Ashes.
						12·62	189	12·62 13·3	175	Saltpetre
R.11	11	K.13	13	Unmanured ...	Unmanured ...	...	...	...	...	

Maize.—The two series bearing maize were treated as follows:—Ploughed once, subsoiled once, cultivated with the planet jr. cultivator four times, and levelled five times with the *pátah*. The manures were applied in June, except saltpetre, which was applied as top-dressing in two instalments, one on the 26th July and the other on the 11th August. Seed was dibbled on the 4th and 6th July, in holes 2 feet by 1 foot apart from each other at the rate of three or four seeds to the hole to guard against contingencies of uneven germination; the rate of seed was about 24 lbs. per acre. When the plants were about a week old the crop was thinned and blanks filled in. Weeded and hoed thrice and earthed up once.

The plants of all plots were laid by the storm of 21st August and by the rainfall and storm of 29th August, and these were lifted and tied. A good deal of injury was also done to the plants by the larvæ of *Chilo Simplex* which also attacks sugarcane and juár. In the early stages several plants were destroyed while in the later some injury was done to the cobs.

The crop was harvested on the 23rd September, and the next table gives the results of both the series for the past year and the previous years.

Acreage outturns (in lbs.) of dry maize

Plot area.	Year.	Cow-dung at 100 lbs. nitrogen.		Cow-dung at 50 lbs. nitrogen.		Residue of cow-dung applied in previous years.		Sheep-dung at 100 lbs. nitrogen.		Sheep-dung at 50 lbs. nitrogen.		Poudrette at 100 lbs. nitrogen.	
		Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.
Each plot is equal to 400 square yards.	Average of 5 years, 1883 to 1886 and 1889.	1,211	1,119	1,442	1,114	1,261	1,006	876	1,003	1,285	880	1,255	1,282
	1890 to 1894 ...	996	744	1,303	906	1,471	906	1,330	1,483	1,529	1,184	1,096	1,528
	1895 ...	2,018	1,004	1,900	1,110	2,105	1,140	2,668	1,189	2,344	1,186	1,945	2,027
	1896 ...	2,541	1,156	1,700	1,385	1,706	1,210	2,813	1,706	2,378	1,809	2,148	1,428
	1897 ...	3,158	2,989	3,243	1,422	3,424	2,452	3,733	1,972	3,025	3,633	3,527	1,794
	1898 ...	1,609	1,343	2,105	1,779	2,226	1,682	2,093	2,009	1,634	1,888	2,323	1,984
	1899 ...	1,634	1,701	2,136	1,331	2,202	1,579	2,393	1,246	2,707	1,516	2,426	2,490
	Average of five years, 1895 to 1899.	2,192	1,639	2,217	1,405	2,333	1,613	2,740	1,624	2,418	2,006	2,474	1,945
	1900 ...	2,698	2,420	3,064	2,641	3,167	2,426	2,989	2,605	3,228	2,559	2,940	2,892
	1901 Grain...	2,538	2,417	2,368	2,017	2,704	1,833	2,468	2,368	3,133	2,102	2,565	2,725
	1901 Straw...	5,832	3,684	7,828	5,360	7,139	3,351	3,509	5,505	5,324	6,207	3,073	8,059

Notes.—(1) The figures for single years from 1882—1894
(2) The years 1887 and 1888 are excluded from the

grain in the standard and alternate series.

Poudrette at 50 lbs. nitrogen.		Saltpetre at 25 lbs. nitrogen.		Saltpetre at 25 lbs. nitrogen and bonedust at 10 lbs. nitrogen.		Saltpetre at 25 lbs. nitrogen and bone superphosphate at 10 lbs. nitrogen.		Ashes of 180 maunds of cowdung.		Ashes of 180 maunds of cowdung and saltpetre at 25 lbs. nitrogen.		No manure.		Remarks.
Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	
1,146	957	1,099	757	1,174	931	1,052	881	821	628	1,207	1,130	617	413	
1,367	1,067	794	778	899	952	1,212	872	682	683	1,276	984	695	570	
2,232	1,325	850	787	1,437	1,089	1,624	898	995	750	1,703	1,007	1,059	774	Alternate B.
2,035	2,021	1,119	714	1,065	430	877	375	1,349	607	910	853	472	200	Do. A.
3,225	2,372	2,544	2,228	2,695	2,493	2,316	1,410	2,411	2,133	2,713	2,015	2,021	1,857	Do. B.
2,396	2,105	1,295	1,222	2,614	1,309	1,888	1,162	1,210	956	2,033	1,730	1,307	460	Do. A.
2,420	2,045	1,997	717	2,329	1,125	1,945	1,237	1,664	871	2,169	1,773	1,476	1,177	Do. B.
2,462	1,974	1,561	1,134	2,028	1,289	1,830	1,016	1,526	1,063	1,906	1,476	1,267	894	
3,182	2,974	2,190	2,257	2,151	2,438	2,738	2,184	1,755	1,712	2,202	2,166	1,682	690	Do. A.
2,925	2,009	2,396	1,912	2,244	2,175	2,196	1,963	1,464	1,452	2,314	2,154	1,730	1,249	Do. B.
6,195	4,828	2,601	5,723	5,384	6,062	3,327	5,384	3,509	5,324	3,533	5,874	4,356	4,066	

will be found in the report for 1900-1901.
averages as the crops were almost entire failures.

Remarks.—The crop would have benefited by rain earlier in September but did not suffer very seriously. The results are generally in accord with previous experience.

Wheat.—The two series bearing wheat were treated as follows:—Ploughed four times, subsoiled once, cultivated four times with the planet jr. cultivator, and levelled with the *patah* six times. The manures were spread on 24th and 25th October 1901, except saltpetre, which was applied in two instalments, one on 17th November 1901 and the other on the 11th December 1901.

The seed was sown on 27th October at the rate of 133 lbs. per acre. So much seed was sown to guard against poor germination. The crop was weeded once, watered thrice and harvested on the 1st April. The results of the last year and of the previous years are given in the next table.

Acreage outturns (in lbs.) of wheat grain in the

Plot area.	Year.	Cow-dung at 100 lbs. nitrogen.		Cow-dung at 50 lbs. nitrogen.		Residue of cow-dung applied in previous years.		Sheep-dung at 100 lbs. nitrogen.		Sheep-dung at 50 lbs. nitrogen.		Poudrette at 100 lbs. nitrogen.	
		Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.
Each plot is equal to 400 square yards.	Average for five years, 1885 to 1889.	1,184	1,394	1,338	1,339	1,258	1,361	1,219	1,517	1,051	1,511	1,253	1,642
	Average for six years, 1890 to 1895.	1,613	1,743	1,685	1,606	1,560	1,581	1,691	1,690	1,694	1,954	1,653	1,792
	1896 ...	2,765	2,184	2,910	1,900	2,904	250	3,001	3,120	3,206	3,104	2,819	3,092
	1897 ...	2,558	2,729	2,472	2,553	2,558	2,716	2,967	2,868	2,107	2,777	2,889	3,219
	1898 ...	2,384	2,202	2,880	2,239	2,069	2,021	2,543	2,880	2,396	2,565	2,202	2,372
	1899 ...	2,184	2,505	2,363	2,384	2,166	2,217	2,505	2,741	2,232	3,028	2,245	2,356
	1900 ...	2,729	2,795	2,937	2,456	2,659	2,229	3,089	3,004	2,741	2,816	2,490	2,598
	Average for five years, 1896 to 1900.	2,524	2,483	2,712	2,306	2,471	2,339	2,821	2,923	2,536	2,858	2,529	2,727
	1901 ...	1,485	1,906	1,652	2,021	1,337	1,960	1,797	1,688	1,431	1,936	1,367	1,676
	1902, Grain...	2,565	3,031	2,686	2,952	2,450	2,426	2,075	2,396	2,414	3,037	2,166	2,608
	1902, Straw...	4,332	4,798	3,255	5,929	4,193	4,538	4,943	5,566	3,999	6,365	3,763	5,136

NOTES.—(1) About a third of this plot has the disadvantage of
(2) The figures for 1883 and 1884 are purposely left out
(3) The figures for single years, from 1885—1895, will be

standard and alternate series.

Poudrette at 50 lbs. nitrogen.		Saltpetre at 25 lbs. nitrogen.		Saltpetre at 25 lb. nitrogen and bonedust at 10 lbs. nitrogen.		Salpetre at 25 lbs. nitrogen and bone-superphosphate at 10 lbs. nitrogen.		Ashes of 180 maunds of cowdung.		Ashes of 180 maunds of cowdung and saltpetre at 25 lbs. nitrogen.		No manure.		Remarks.
Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	Standard.	Alternate.	
1,177	1,325	1,314	1,406	1,398	1,726	1,131	1,557	829	1,246	1,208	1,405	888	1,082	
1,797	1,874	1,481	1,573	1,484	1,748	1,681	1,704	1,339	1,448	1,568	1,731	1,104	1,308	
3,146	2,983	1,839	2,353	2,063	1,516	2,426	1,927	2,202	2,090	2,396	2,408	2,257	1,183	Alternate A.
2,466	2,952	1,853	2,535	1,948	2,589	2,236	2,559	1,757	1,785	2,188	2,474	1,723	1,936	Do. B.
2,263	2,553	1,851	2,045	2,154	2,263	2,468	2,360	1,742	1,307	1,827	2,142	1,416	1,246	Do. A.
2,680	2,898	2,242	2,608	2,287	2,689	2,360	2,602	1,851	1,761	1,567	1,597	1,386	1,658	Do. B.
3,004	2,952	2,323	2,768	2,420	2,592	2,961	2,704	2,154	1,779	2,251	2,444	1,951	1,500	Do. A.
2,712	2,868	2,022	2,462	2,174	2,330	2,490	2,430	1,941	1,744	2,046	2,213	1,747	1,505	
1,434	1,588	1,077	2,118	1,379	1,960	1,621	1,821	1,071	1,473	1,506	1,900	1,189	1,410	Do. B.
2,719	2,810	2,220	2,577	2,205	2,668	2,650	2,771	2,353	2,565	2,323	2,335	1,936	1,724	Do. A.
4,819	6,398	3,842	5,094	4,196	5,245	3,315	6,921	3,406	3,194	3,727	2,662	3,098	2,620	

adjoining trees, and bears every year a strikingly poorer crop than the rest of the plot.
of account.
found in the report for 1900-1901.

Remarks.—The yield has been exceptionally good; there was no rust, and only slight damage was done by laying and by rats.

Green manuring.

The scheme of this experiment has hitherto been as given below :—

G. 1.—Indigo refuse, one year old, ploughed in at 120 maunds per acre.

G. 2. Fresh indigo refuse ploughed in at 120 maunds per acre.

G. 8. Green indigo crops ploughed in.

G. 7. Green hemp ploughed in.

G. 3. Green urd ploughed in.

G. 5. No manure.

27-A. 1. Green hemp ploughed in.

27-A. 2. Green khurti (*Dolichos biflorus*) ploughed in.

27-A. 3. Green urd ploughed in.

27-A. 4. No manure.

The first six plots have, for some seasons, been regarded as unsatisfactory : a careful analysis of past results has shown that the position of the individual plots was more important than the treatment in determining the outturn, and after discussing the matter with the Inspector-General of Agriculture I decided to abandon the plots and to start a more complete experiment on another part of the farm. Accordingly the outturns of the past years are not printed. The remaining four plots are incorporated in the new experiment. The following weights of green crops were ploughed in :—

27-A. 1. Green hemp ... ... 20,903 lbs. per acre.

27-A. 2. Green khurti ... ... 7,664 lbs. ditto.

27-A. 3. Green urd ... ... 6,920 lbs. ditto.

The practice of cutting and chaffing the green plants was followed; it is however open to obvious objections and will not be repeated. After spreading the green stuff, the plots were ploughed three times subsoiled once, cultivated twice with the planet jr. cultivator and levelled five times with the *patah*. Seed was sown on the 25th and 26th October at the rate of 120 lbs. per acre. The crop was weeded once watered twice and harvested on 3rd April. The results of the past year and the previous years are given in the following table :—

Acreage outturns of wheat on the green manured plots.

Plot number.	Plot area.	Treatment.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Average of 5 years, 1896—1900.	1901.	1902.	
												Grain.	Straw.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Square yards.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
27*a* 1	778	Green hemp ploughed in.	837	264	975	909	1,057	1,171	1,434	1,109	636	1,244	2,146
27*a* 2	778	Green khurti ploughed in.	858	206	1,058	1,200	983	1,325	1,610	1,235	529	1,238	2,161
27*a* 3	940	Green urd ploughed in.	720	370	791	713	762	940	1,009	843	551	1,138	1,957
27*a* 4	890	No manure ...	541	414	1,138	888	897	1,263	1,203	1,078	544	1,305	2,224

Rotation of wheat and leguminosæ.

This experiment was carried on in the same field as the plots referred to above and has been abandoned for the reasons there stated, its place being taken by a new experiment now being started. Accordingly the results are not printed.

Manurial experiment with sugarcane.

This experiment in its present form was started in 1896 by the Agricultural Chemist to the Government of India. The variety of sugarcane tried is the chewing form known in these provinces as Madrasi. As the crop occupies the land for about 11 months, and as, in order to save time, it is desirable that it be grown every year without break so long as the experiment lasts, two sets of ten plots each have been allotted for the purpose in two different parts of the farm; ten plots on field Nos. 29 and 30 and the other ten plots on Nos. 37, 38 and 39. These two sets are sown with sugarcane in alternate years; and in order to work out the manure residue each series bears unmanured an intermediate crop. Until 1899 potatoes were sown for this purpose, but since that year a rain cereal, sawan (Panicum frumentaceum), a cheaper and easier crop to grow, has been substituted. Experience has however shown that it cannot cope with the weeds on the highly manured plots, and therefore leaves the land foul and some other crop will be substituted next year.

Details of cultivation.—After cutting the sawan crop the plots in fields Nos. 29 and 30 were ploughed four times, subsoiled once, cultivated once with the planet jr. cultivator and levelled five times with the *patah*. Manures were applied on different dates in the month of January and February 1901. On the 7th to 11th February selected cuttings were planted as usual on the ridge and furrow system, the ridges being 30 inches apart. The crop was irrigated 14 times in all, weeded twice, dug twice and earthed up once.

The harvesting of the series began on the 21st January and continued up to the 2nd February 1902.

Some of the plots in this experiment were attacked by the borer. In these cases the injured portion of the field was measured off, and the outturn per acre calculated from the uninjured area. In most cases the injury was confined to a corner of the plot, but in plots 6 and 8 the area injured was extensive and the figures given for these plots must be taken with some caution.

Results obtained with several manures applied to sugarcane, 1901-1902.

Plot No.	Plot area.	Treatment.	Actual quantities of manure applied per acre.	Outturn per acre.			Percentage.			Remarks.
				Canes.	Juice.	Gur.	Juice to canes.	Gur to juice.	Gur to canes.	
				lbs.	lbs.	lbs.				
29 & 30 / 1	Each plot=1,210 square yards.	Unmanured	...	8,196	4,528	778	55·25	17·18	9·49	
29 & 30 / 2		Cow-dung at 125 lbs. nitrogen per acre.	34722·22	13,500	6,212	1,032	46·01	16·61	7·64	
29 & 30 / 3		Cow-dung at 250 lbs. nitrogen per acre.	79444·44	16,710	11,602	2,015	69·43	17·37	12·06	
29 & 30 / 4		Cow-dung at 500 lbs. nitrogen per acre.	158388·88	29,288	18,876	3,016	64·45	15·98	10·30	
29 & 30 / 5		Poudrette at 250 lbs. nitrogen per acre.	67567·57	23,136	13,101	2,256	56·63	17·22	9·75	
29 & 30 / 6		Poudrette at 500 lbs. nitrogen per acre.	135135·14	26,448	16,536	2,844	62·52	17·19	10·75	Half the plot injured by borer.
29 & 30 / 7		Saltpetre and super-phosphate each @ 125 lbs. nitrogen per acre.	990·49 & 5278·56	26,004	14,480	2,422	55·68	16·73	9·31	
29 & 30 / 8		Saltpetre and bone-dust each @ 125 lbs. nitrogen per acre.	990·49 & 3443·2	17,038	7,750	1,355	46·72	17·48	7·95	Half the plot injured by borer.
29 & 30 / 9		Castor cake at 250 lbs. nitrogen per acre.	3765·06	...	10,984	1,904	...	17·33	...	
29 & 30 / 10		Caster cake at 500 lbs. nitrogen per acre.	7530·12	25,392	15,104	2,608	59·48	16·61	10·27	

Manurial experiment with potatoes.

This experiment was started at the instance of the Agricultural Chemist in 1896. The variety grown is the common white-skinned country variety known locally as Madrasi. The scheme of the manurial treatment continued the same as in the previous year. The manures are applied before planting potatoes; and with a view to work out the manure residues and to secure the most economical results possible for the expenditure incurred on the manures, a crop of maize is also grown in the interval between two crops of potatoes, without any other application of manure.

Details of cultivation.—Ploughed once, subsoiled once, cultivated with the planet jr. cultivator twice, levelled with the *patah* four times. Manures were spread on the 28th October 1901. Planted whole tubers in lines 20 inches apart, the holes in the lines being about 10 inches apart. After planting ridges were made all along these lines by throwing earth with *phaoras* from both sides. The crop was earthed up twice, watered five times and dug on the 1st to 12th March 1902.

Acreage outturns of potatoes and maize grown with different manures.

Plot No.	Plot area.	Manure applied per acre.	Actual quantities of manure applied per acre in 1901-1902.	Potatoes.							Maize.					Average of five years.
				1896-97.	1897-98.	1898-99.	1899-1900.	1900-1901.	1901-1902.	Average of six years.	1897.	1898.	1899.	1900.	1901.	
			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
25/1	Each plot=484 square yards.	Unmanured	...	9,830	6,500	7,860	13,710	6,915	7,090	8,650	3,130	1,920	1,100	2,720	1,625	2,099
25/2		Poudrette at 200 lbs. nitrogen per acre.	48780·48	7,720	11,640	8,540	22,250	16,870	19,830	14,475	3,490	2,740	2,153	3,680	2,460	2,905
25/3		Poudrette at 100 lbs. nitrogen per acre.	24390·24	5,700	9,730	9,170	17,070	12,365	13,390	11,237	3,265	2,440	1,733	3,690	2,315	2,689
24/4		Cow-dung at 200 lbs. nitrogen per acre.	54054·06	9,730	9,130	8,870	20,460	15,940	15,820	13,325	3,038	2,390	1,170	2,580	2,550	2,346
24/5		Cow-dung at 100 lbs. nitrogen per acre.	27027·03	9,260	7,340	9,140	15,910	9,775	9,910	10,223	2,955	1,720	1,030	2,965	2,325	2,199
24/6		Castor at 200 lbs. nitrogen per acre.	2962·96	4,740	9,410	12,170	18,630	22,530	13,740	13,537	2,693	1,570	1,280	2,760	1,860	2,033
24/7		Castor at 100 lbs. nitrogen per acre.	1481·48	8,430	10,280	11,610	15,100	15,010	10,750	11,863	2,533	1,910	1,240	2,780	1,995	2,092
26b/8		Saltpetre and bone-dust each at 50 lbs. nitrogen per acre.	396·35 1597·44	7,960	9,200	13,500	16,920	10,180	8,620	11,063	2,958	2,170	1,705	2,870	2,367	2,414
26b/9		Saltpetre at 50 lbs nitrogen per acre.	396 19	6,780	10,000	7,160	15,760	11,830	9,090	10,103	3,043	1,980	1,260	2,820	3,440	2,509
26b/10		Unmanured	...	4,080	8,160	2,900	9,820	5,470	4,560	5,832	3,005	1,840	988	2,380	1,890	2,021
		Average of the two unmanured plots.	...	6,955	7,330	5,380	11,765	6,193	5,825	7,237	3,068	1,880	1,044	2,550	1,758	2,060

4.—TRIALS OF DIFFERENT VARIETIES OF CROPS.

Sugarcane varieties.—This experiment was started in its present form in 1896 at the instance of the Agricultural Chemist to the Government of India. Six varieties are under trials with large quantities of manure. Three of these known respectively as Saharanpuri, Madrasi and Poona varieties, are usually grown in these provinces for consumption as fruit, but at the Farm they are experimentally used for the manufacture of sugar. The other three varieties are *dikchan*, *dhaul* and *matna*, all of which are important local varieties. These three are grown in single plots, each receiving poudrette at 250 lbs. nitrogen per acre: the thicker canes are grown in two series, one receiving 250 lbs. nitrogen, the others 500 lbs. nitrogen per acre. As the crop can only be sown once in two years on the same plot, there are in all 18 plots covering an area of 1·75 acres. During alternate seasons a crop of sanwan (Panicum frumentaceum) is taken to work out the manurial residues.

Details of cultivation.—Ploughed thrice, subsoiled once, cultivated with planet jr. cultivator once, and levelled with *patah* four times. Plots receiving poudrette at 500 lbs. nitrogen per acre received one additional ploughing. The manures were applied on the plots treated with 500 lbs. nitrogen per acre on the 29th to 31st January, and on those which received 250 lbs. nitrogen per acre on the 30th and 31st January 1901.

Cuttings were planted on the 5th and 6th February 1901 as usual on the ridge and furrow system with ridges 30 inches apart. The crop was weeded thrice, dug twice, earthed up once. The local varieties of *ukh* were lifted up, and two to four stools were tied up together in order to keep them erect.

The chewing varieties were watered fourteen times, and the local *ukh* varieties eleven times in all. Cutting and crushing began on the 2nd February and finished on the 8th February 1902. The results of the experiment are given in the next table.

The crops suffered somewhat from want of rain in September, with the result that the juice was reduced in quantity but was comparatively rich in sugar.

Field number.	Plot area.	Treatment.	Actual quantity of manure per acre.	Name of variety.	Outturn in pounds per acre.			Juice to cane.	Gur to juice.	Gur to cane.
					Canes.	Juice.	Gur.			
West ... 1	Each plot $\frac{1}{16}$th of an acre. Each plot $\frac{1}{8}$th of an acre.	Poudrette yielding 500 lbs. nitrogen per acre.	135,135	Saháranpuri Pounda.	36,040	20,592	3,536	57·14	17·17	9·81
West ... 2		Ditto ...	135,135	Madrasi Pounda.	47,808	28,864	4,808	60 37	16·66	10·06
West ... 3		Ditto ...	135,135	Poona Pounda.	33,600	20,192	3,344	60·1	16·56	9·95
East ... 1		Poudrette yielding 250 lbs. nitrogen per acre.	67567·5	Saháranpuri Pounda.	40,512	17,856	3,472	44·08	19·44	8·57
East ... 2		Ditto ...	67597·5	Madrasi Pounda.	30,912	19,712	3,568	63·77	18·1	11·54
East ... 3		Ditto ...	67567·5	Poona Pounda.	16,128	8,800	1,328	54·57	15·09	8·23
East ... 4		Ditto ...	67567·5	Dickchan ukh.	22,400	12,832	1,728	57·29	13·47	7·71
East ... 5		Ditto ...	67567·5	Dhaul ukh...	30,240	15,424	2,464	51·01	15·98	8·15
East ... 6		Ditto ...	67567·5	Matna ukh...	27,584	14,272	2,064	51·74	14·46	7·48

Potatoes.—The three varieties under trial are (1) Madrasi white, (2) Country red and (3) Hill variety.

Details of cultivation.

Tillage.—Ploughed twice, subsoiled once, cultivated with the planet jr. horse hoe twice and levelled with *patah* 5 times. Poudrette at 200 lbs. nitrogen per acre was applied on 1st November 1901. On 3rd to 5th November 1901 whole tubers for the two country varieties and cut sets and whole tubers of the hill variety were dibbled in holes made with *khurpis* in regular lines on the flat ground. These lines were subsequently made into ridges by throwing earth over them.

The distance between the ridges for the Madrasi was 20 inches apart and between the holes in the row 10 inches, while for the country and hill varieties the rows

were 21 inches apart and the seed in the rows one foot apart. The weight of the seed used for the Madrasi variety comes to 1,024 lbs. per acre, that for the red variety to 824 lbs. and that for hill variety to 1,344 lbs. The crop was earthed up twice, watered five times and harvested on different dates between 13th March and 12th April 1902.

The following statement gives the outturns obtained :—

Plot number.	Plot area.	Name of variety.	1898-99.	1899-1900.	1900-1901.	1901-1902.
			lbs.	lbs.	lbs.	lbs.
26A/1	Each plot 1,210 square yards.	Madrasi white...	12,928	16,660	16,152	10,908
26A/2		Country red ...	11,772	19,700	17,312	11,300
26A/3		Hill variety ...	10,016	11,488	16,596	5,780

The hill variety suffered greatly from rotting of the sets planted and poor germination. Regarding the difference of time in germination remarked on in last year's reports the earliest sprouts of the Madrasi were noticed on the 12th day after planting, those of the red country on the 17th day and those of the hill variety on 21st day. The Madrasi took about a fortnight less than the red country to mature, and red country a similar time less than the hill variety.

Cotton.—The trials of foreign varieties of cotton which were described in detail in a bulletin published last year were continued during the year under report.

Details of cultivation.—The land was ploughed thrice with the Watt's plough, subsoiled once, cultivated with the planet jr. cultivator once, and levelled five times with the *patah* Cow-dung at 200 maunds per acre was applied on the 18th June 1901. Seed was dibbled on the 17th July 1901 in holes one foot apart, along lines made in the fields at the intervals of three feet. The weaker and unhealthy looking plants were pulled out about ten days after sowing and the blank spaces were filled in by fresh sowing. The crop was weeded twice, dug thrice, watered twice and picking began in November and closed about the end of February. For the second crop in the hot weather the land was watered thrice and was intercultured once with the planet jr. cultivator. Picking commenced in April.

The results of the past year and the previous years since 1895, are given in the following table. Two varieties of cotton—Sea Island and Upland—received from the United States were also sown in small patches of ground; but their outturn need not be given at present as they are not acclimatized.

Acreage outturn in lbs. of clear fibre from different varieties of cotton.

Name of variety.	1895.		1896.	1897.	1898.	1899-1900.		1900-1901.	1901-1902.			
									Fibre.		Seed.	
	First crop.	Second crop.				First crop.	Second crop.	First crop.	First crop.	Second crop	First crop.	Second crop.
Wattagodu ...	...	...	...	...	86	300	300	224	259	217	525	420
Allen ...	...	...	...	...	29	248	156	201	266	147	567	315
Cook's long staple	...	...	...	...	67	219	300	74	125	150	275	320
Cawnpore farm variety No. 1,	310	223	217	176	304	308	260	340	285	260	610	510
Hybrid ...	289	195	285	150	249	348	300	317	325	330	680	695
Cawnpore country ...	...	...	411	80	221	228	290	336	258	138	612	330

Note.—No second crop was taken in 1900-1901.

In the month of August the plants were attacked by a small borer (Earias fabia, *Stoll.*) identified for the first time attacking cotton, but known as attacking the common "Bhindi" (Hibiscus Esculentus) and other

malvaceæ. There are possibly two generations, the first tunnelling into the young shoots which wither and dry up, the second into the flowers destroying the young bolls (ovaries). On the first signs of withering the injured portions of the plant containing the borer were cut off and burnt. The shoots of nearly every plant were attacked, but not many bolls. The treatment appeared effective as the pest disappeared, the plants suffering practically no injury. *Aphis* were also troublesome at one time especially on Cook's long staple which had already suffered more than the others from waterlogging, hence this latter cause of injury was not noticed until rather late. Spraying with a kerosene solution was tried, but did no good; the *aphis* being on the under surface of the leaf are difficult to get at effectively.

Trial of a hard wheat.—This wheat was received from the Political Agent in Bundelkhand, who had found it growing free from rust in the garden of a native chief, while neighbouring fields were attacked by the disease. It has been under trial since 1895, and was grown in different plots during this period. For the first three years it remained quite free from rust, but during 1898-99 it suffered as much as the Muzaffarnagar wheat and in 1900-1901 it rusted very badly. The trial will now be discontinued as it is not rust-resisting in this climate.

Tapioca.—The roots of the tapioca cuttings received from Travancore and Tanjore in the previous year were dug in the months of December and January and starch was extracted from them. It appears from observation that the tapioca received is of two kinds. The roots of that received from Travancore are starchy and those from Tanjore woody; there are also differences in the roots and stems of the plants. Pending analysis (which could not be arranged for this year as the Agricultural Chemist was on tour), no opinion can be given as to the suitability of the plant for this climate.

Marsh's selected Barley.—This barley was sown in the month of October 1901 and harvested on 30th March 1902. An area of 400 square yards was given to the crop. No watering was given.

Only a few ounces of grain were obtained as practically the whole crop withered owing to the drought in the cold weather. The country barley which was sown in an adjacent plot of the same area with the same treatment also withered and yielded only 48 lbs. of grain per acre. The claim of Marsh's variety to drought-resistance was however definitely negatived so far as this locality is concerned by the experience of the year, and the trials will now be closed.

Juar.—A large number of varieties, or supposed varieties, about 90 from these Provinces and eleven from Central and Western India, are still under examination and some approach has been made towards a satisfactory classification. The work is however very laborious and the results are not yet far enough advanced for publication.

Maize.—Two common North-Indian varieties and four American varieties were cultivated and kept under observation. This year these varieties were grown in plots separated by wider spaces to guard against natural cross fertilization. A certain amount of crossing however occurred and the stock of seed will have to be purified by further cultivation before proper selection can begin.

Kabuli gram.—During the last four years this crop has been cultivated on a small area at this station with the object of studying its habit and characters as compared with the ordinary gram, and of raising a small quantity of seed for supply to the public. The grain is white, larger, fuller and smoother, and presents a more attractive appearance than the ordinary gram. The plants also are larger and bushy with larger leaves and white flowers and with the roots better provided with tubercles than even the country gram which is one of the best of our crops in this respect.

So far the variety appears to be deficient in grain-yielding power compared with the country kind: the year's outturn is shown in the following table :—

Acreage outturns of Kabuli and country grams for 1901-1902.

Plot number.	Plot area.	Crop.	Outturn per acre.	
			Gram.	Haulms.
			lbs.	lbs.
26B/1	Each plot=484 square yards.	Country gram ...	1,600	2,780
26B/4		Kabuli gram ...	590	1,160
26B/5		Country gram ...	1,290	1,490

Huskless Barley.—The peculiarity of this variety consists as the name indicates in the grain having no husk, consequently from an equal weight of grain the huskless barley will give a greater amount of flour as compared with the ordinary variety. It, is however, more delicate, less productive, and takes apparently about seven to ten days more for maturing than the ordinary country barley. This year the yield was only 157 lbs. of grain and 363 lbs. of straw per acre. There is little practical importance or promise about this variety.

Sugarcane.—Besides the six varieties already noticed as being under systematic trial 18 varieties of thin canes grown in these provinces and two varieties of thick canes (received from Burdwan and Meerut respectivly) were also cultivated during the past year. Some of them promised very well for making sugar while of others the area sown was insufficient for gur-making; all of these varieties are again sown this year for further study.

5.—MISCELLANEOUS EXPERIMENTS.

Deep and shallow tillage.—This experiment was started in 1882 with the object of seeing what the effect of deep and shallow ploughing would be on wheat when no manure was applied. The original scheme of the experiment was however defective and has recently been altered. The present scheme is as follows :—

There are three plots, the area of each of them being one-fourth of an acre, each plot receiving cow-dung at the rate of 100 lbs. nitrogen per acre. The tillage operations are : for plot No. 1, subsoiling twice 8″ to 9″ deep, followed by two ploughings with the country plough; for plot No. 2 ploughing twice with the Watt's plough 5″ deep followed by two ploughings with the country plough; for plot No. 3 eight ploughings with the country plough. The only other implement that was used on these plots was the *patah*.

The outturns obtained since the change in conditions are as follows :—

Acreage outturn of wheat on plots ploughed in three different ways.

Year.	Plot No. 1, ploughed 8″ deep.	Plot No. 2, ploughed 5″ deep.	Plot No. 3, ploughed 4″ deep.
1901	960	813	779
1902 Grain	1,692	1,756	1,455
1902 Straw	3,584	3,080	3,677

Early and late sowing of maize.—This experiment was started in 1887, having for its object the determination of the effect of early and late sowing on the yield of maize. The experiment is carried out in

three plots, each of 708 square yards. The dates of sowing were 14th June, 7th July and 28th July. Farmyard manure was applied at the rate of 200 maunds per acre. The following statement shows the outturn obtained :—

The early and late sowing of maize.

Plot number.	Time of sowing.	Outturn per acre in lbs.									
		Average 1887-88 to 1891-92.	1892-93.	1893-94.	1894-95.	1895-96.	1896-97.	1897-98.	1898-99.	1899-1900.	1900-1901.	1901-1902.
A. C. / 1	Early ...	1,451	1,678	1,825	213	553	260	1,532	1,809	1,062	2,418	1,941
17 A,	Intermediate ...	1,169	1,928	1,591	276	1,053	1,322	1,132	1,608	716	2,616	1,845
A. C. / 2	Late ...	...	...	...	...	...	...	...	762	282	2,096	1,623

Cotton and maize in alternate rows.—Jaunpur maize and Cook's long staple cotton were sown in the rains in alternate rows by dibbling the seeds in holes. The distance of maize was three feet from row to row and one foot from plant to plant and the same distance for the cotton. The object of the experiment is to ascertain the results of growing these crops simultaneously ; the combination of a food crop and a cash crop is obviously desirable, provided the two do not interfere with one another. The following statement shows the outturn obtained per acre :—

Plot number.	Plot area.	Crop.	Yield in lbs.	Yield in lbs.	Remarks.
26 B / 2 and 3	$\frac{1}{6}$ acre	Jaunpur maize-grain ...	1,761		
			First crop.	*Second crop.*	
		Cook's long-staple cotton :			
		Fibre	80	57½	
		Seed	157	112	

Crossing maize.—Attempts continued to raise a stock of maize by crossing an American variety (Dent Field corn) on Jaunpur. No results of value have been obtained.

Raising pedigree maize.—Two varieties—Jaunpur maize and American yellow Dent Field corn—are being cultivated in order to raise pedigree strains : the experiment was started in 1900. The cultivation was generally similar to that adopted in the other maize plots on the farm. In 1900 the Jaunpur maize gave 1,980 lbs. per acre ; cobs from the best plants were carefully set aside and seed from them sown in July 1901.

The yield was at the rate of 4,800 lbs. per acre ; cobs from the best plants have again been selected for seed. The same process was followed in the case of Dent corn, which yielded 1,445 lbs. in 1900 and 3,060 lbs. in 1901.

It cannot be inferred that the sudden rise in yield was due solely to the better seed, as the seasons differed materially.

CHAPTER II.—Reclamation of barren land.

A full account of the work of the department in past years will be found in Agricultural Ledger No. 13 of 1901; the last chapter of that ledger indicates the programme for future work fixed in consultation with the experts of the Imperial Agriculture Department.

Tree planting.—The deep thala plantations continue under observation. The condition of the large babul plantation at Abbaspur has fallen off, but it would be premature to draw any inference for some time yet. The small plantation in the alkali land at Gursikran is flourishing, but I have not had time recently to examine it in detail. The plantations in the Juhi reserve, the soil of which is very slightly alkaline, have been examined minutely; so far babul has done far the best, the percentage of success to plantings being about 82; shisham and nim have percentages of only 49 and 55, and certainly could not pay; mahua has a percentage of 43, excluding the plot planted last year, which was attacked by hares and ruined very soon after planting. The growth of the mahua is slow but the trees seem to be establishing themselves.

Most of the plantations are now large enough for experimental purposes, and it is intended to extend only the mahua plantation during the current year, and to plant out some rain-trees, which have been recommended by the Director of the Botanical Department.

Removal of alkali by subsoil drainage.—A plot was drained in May 1900, the slope of the pipes being made considerably greater than the usual English practice in order to avoid the silting up that had occurred in former experiments. During the first season the drains worked well, and discharged a large amount of water which contained great quantities of alkali; the amounts were determined for each day that the drains ran. In the second year, however, the drain ceased to run, and examination showed that despite the precautions taken it had almost entirely silted up. The pipes have now been relaid on lines recommended by the Deputy Director and a further trial is in progress. The results obtained in 1900 are given below:—

Date on which drain ran.	Approximate quantity of drainage.	Amount of alkali in one cubic foot.	Remarks.
	C. ft.	Grams.	
July, 5th	...	30·0	Quantity not measured on these dates.
„ 12th, 13th ...	...	111·4	
„ 29th	200	50·8	
August 11th ...	400	97·1	
„ 14th, 15th ...	330	38·9	
„ 24th, 25th ...	14	28·3	
„ 26th ...	10	45·4	
„ 27th ...	10	67·7	
September, 1st ...	350	57·1	
„ 6th, 10th ...	1,200	32·3	
„ 12th, 14th ..	420	21·0	
„ 19th, 20th ...	370	20·6	
December, 2nd ...	300	24·3	
„ 13th ...	600	68·3	

The measurements of quantity of drainage are necessarily very rough and cannot be relied on for accurate calculations: the amount of alkali in the water was determined with fair accuracy. The figures suggest that the alkali removed during the season was at the rate of from 400 to 500 lbs. per acre; the alkali present in the land probably amounts to 100,000 lbs. in the first two feet, analysis showing that it exceeds 1 per cent. of the total soil. Removal of salts by drainage would therefore be an exceedingly slow process: on the other hand the season was much drier than usual and with fair rains the quantity removed would probably be very much greater.

An alternative method of drainage is contemplated by perforating the soil down to the water stratum. I had hoped to have a plot treated this way in time for the rains, but unfortunately the auger used in the work was stolen, and no other could be got in the country, so that operations have been delayed pending the arrival of tools from England.

Removing of alkali by scraping.—A plot was cleared of grass during last rains so that as much alkali as possible might come to the surface. In February it was found to be covered with a very thick deposit; analysis showed that the soil contained originally from one to two per cent. of alkali, half of which was sulphate and half carbonate; the deposit was scraped off, and the scrapings removed to a safe distance. After this the land was flooded and a second layer of alkali removed in the end of May. This process will be repeated for some years, in order to see if the amount of alkali can be so reduced at a reasonable cost as to facilitate reclamation by other means.

Use of lime.—Two plots in the Juhi reserve (not alkaline) have been treated with lime and cultivated. There is a distinct improvement in the soil so treated, but the weather conditions at this reserve were so bad that the results of cultivation are not worth recording: the rain came very late, and the September rain that did such enormous good to most parts of the provinces scarcely touched the reserve.

Ploughing in green crops.—The experiments were continued at Juhi, but the season was so unfavourable that the results are not worth recording. In order to get an autumn crop ploughed in in proper time it is essential that sowings should be effected early, but the lateness of the rains prevented this and the growth was too poor to produce much effect.

Burning.—The soil of a small plot at Juhi has been burnt under the supervision of the Deputy Director, and its capacity will be tested during the coming year. If improvement is found to result experiments on a larger scale to determine the cost of the process will be under taken.

Trial of new plants.—My attention was called during the year by Mr. A. C. Walker, I.C.S., to the fact that the tanning shrub named *Cassia auriculata* had apparently established itself on a piece of barren land in the Etáwah district, and I directed its trial on our reserves. The trials in the alkali soil at Gursikran were a failure; those in the heavy clay of Juhi were unsatisfactory and will be repeated.

Trials of the saltbush, *atriplex semibaccata* were made in the alkali soil, but failed, owing, apparently, to defective seed; the trials will be repeated if I can get enough good seed.

Several other varieties of saltbush were planted out in the Juhi clay but all died out before the hot weather.

Hay-making.—The yield at Juhi was 32 maunds, or nearly 1¼ tons per acre. Two stacks of hay have been thatched at Gursikran and will be left for some time to see if the hay will keep in this climate.

CHAPTER III.—Investigations regarding wheat rusts.

I have only noticed so far two species of rust on the wheat of this country.

1. The Indian *Puccinia Graminis* "Streaky Rust."

2. A species resembling probably most nearly *Puccinia Glumarum, Eriks* and *Henn.* "Spotted Rust." The terms "streaky" and "spotted" appear as good as any others for these two rusts denoting as they do the general appearance of the pustule on the plant. It is true that *Puccinia Graminis* in the early stages sometimes has a spotted appearance on the leaves, but the pustules have a darker colour being more of a brick red, while the real spotted is lemon or yellow in colour.

The Indian *Puccinia Graminis* resembles the European variety very nearly, except that I have not seen the teleutospore pustules on the leaves as they occur in Europe.

The barberry plant is certainly absent from the plains, but this phase of the life history of *Puccinia Graminis* as it occurs in Europe has never been quite accepted as the only method by which the disease is continued from year to year. So that unless some quite different host in the place of the barberry is found, the difference is not so great that the term *Puccinia Graminis* of India is not suitable.

There is in India a form on wheat, barley and rye; I have not seen any form on oats, as occurs in Europe. All three appeared to be attacked in about an equal manner. The disease appears later than the spotted rust, at least these last two years it has done so. It does not appear to commence below and creep upwards or attack any particular part of the plant first and there may be pustules on the culm below the head without the disease appearing bad on the sheaths and leaves below. The leaves, sheaths, culm and head may be all attacked. Generally the disease has more the appearance of attacking the sheaths and upper culm than the leaves. But in bad cases I do not see much difference from *Puccinia Graminis* in Europe, as regards method of attack, except that I have not noticed the teleutospore pustules on the leaves. In 1901 when the wheat suffered so much from rust, as far as my observation extended round Cawnpore and through Bundelkhand the real damage did not appear to be done by this rust (though of course it helped) with the exception of the foreign wheat in the Experimental Farm which was sown rather late, some wheat I saw in Jhánsi, and odd plants which were late in ripening.

In the bad cases the upper surface of the leaves were covered with uredospore pustules, likewise the sheath, culm and head: in the latter stages teleutospore pustules were very prominent on the sheath and upper culm, parts being covered close with them. On the other hand the leaves are often so covered with the spotted variety that when only slightly affected by *Puccinia Graminis* and in the early stages the uredospore pustules of the latter are not very observable with the naked eye; whereas on the sheaths the pustules running more into lines makes them more noticeable on this part. I have not noticed this rust spreading from any particular centre of a field.

*Appearance of pustules and spores.**—The uredospore pustules are of a brick red colour, oval, linear and sometimes coalescing laterally, always form long lines on the sheaths, but shorter or oval on the leaves. They become more of a brown colour as the straw ripens.

The uredospores are elliptical, Pyriform or ovate, warm yellow, echinulate.

Teleutospore pustules black linear rupturing epidermis forming lines on the sheath and upper culm not noticeable on leaves; sometimes becoming confluent laterally.

Teleutospores, chestnut brown, fusiform (spindle shaped) or club-shaped, Apex pointed, sometimes rounded, thickened pedical long.

"*Spotted Rust.*"—This rust resembles *Puccinia Glumarum, Eriks and Henn.* It likewise has a form on barley as well as wheat. It certainly differs in the absence of paraphyses. The barley does not appear to be infected from wheat. In some fields of mixed barley and wheat round Cawnpore the wheat was badly affected, while the barley was unattacked†. The disease on barley appeared later.

* The microscope at present in use is not sufficiently good to enable a complete description to be given: better appliances have been ordered for use in the current year.

† Morphologically the disease appears the same.

The rust on wheat made its appearance this year about the middle of January, last year it appeared earlier.

The radical leaves are attacked first and if the conditions are favourable, as last year, almost in a day it seems to leap into existence, the lower leaves of nearly every plant being smothered with pustules and the production of uredospores so profuse that the soil may become red with the spores, then the lower leaves rapidly wither and become attacked by other fungi. This attack on the lower leaves comes almost like a blast and then the disease spreads upwards more or less quickly according to the weather; heavy dews and cloudy weather giving every spore a chance to germinate, and every part of the plant may be attacked.

But the disease may be said to be most distinctly marked on the leaves; should the season be bad and the disease spread to the head, the attack also becomes distinctly marked on the glumes, the uredospore pustules occurring outside the glumes, inside the glumes and on the tip of the grain and on the awns. The pustules are common on the leaf sheaths but never occur to that overwhelming extent that they do on the leaves.

These pustules on the whole are most marked on the upper surface of the leaf and may sometimes be seen on the upper surface without any below, but I have never seen a leaf attacked on the lower surface without pustules being present on the upper. The pustules usually make their appearance first on upper surface of leaf and generally the pustules below are these burst through, but they may also occur on the lower side independently though more rarely.

Under less favourable circumstances the attack is not so remarkable. Thus in light attacks the disease sometimes has the appearance of only appearing on that part of the leaf blade nearest the stem, in the case of the upper leaves, though the radical leaves are always attacked and generally wither, even in such cases there are nearly always a few uredospore pustules on the leaf sheaths, but the disease does not reach the head before the glumes have become too hard.

The teleutospore pustules are found on the under surface of the leaf, on the leaf sheaths and also occurring on the head when that part is attacked. They do not rupture the epidermis. Amongst the upper leaves of a crop attacked, it may often be noticed before the uredospore pustules break out that the green colouring matter of the leaves has disappeared in spots and blotches and is replaced by the yellow colouring matter of the fungus.

Appearance of pustules and spores.—The uredospore pustules are of a lemon yellow colour very small, not occurring in groups, but scattered over the surface, oval in shape, but often from their small size appear round to the naked eye. They do not generally coalesce laterally though this occurs sometimes when attack is bad, and in advanced stages. Longitudinal coalescence occurs rather more frequently under similar conditions forming rather longer linear sori, but this is not the general character. Uredespores yellow, round, a few sometimes shortly elliptical, echinulate.

Teleutospore pustules, brownish, black spotted or linear. Yellow spotted and streaky pustules also occur, these are unripe teleutospores.

Teleutospores do not rupture epidermis, are shortly stalked brown two-celled, club shaped, apex truncate or obliquely conical. Paraphyses not present.

In my tour through Budelkhand last cold weather I enquired from cultivators all along the route if they had noticed any plant near a field or in the field, from which the rust on the wheat seemed to start and without exception I got a negative reply, and personally no intermediate host has been seen. Rust occurs on *dub* grass, (Cynodon Dactylon) and on *motha*, (Cyperus), but has no connection with the rust on wheat.

I have endeavoured to test the possibility of the disease being carried over from year to year by the uredospores. For this purpose I collected at harvest time some of the worst rusted straw and buried it about 6 inches deep (April 1901). The following October 1901 and again in January 1902 when I returned from camp I failed to get either the uredospores or teleutospores to germinate. Some of the uredospores looked quite healthy when first examined after being dug up. Though I had selected the worst rusted straw and buried it together, the uredospores were not found so easily as I had hoped and therefore I was not able to examine as large a number as I could have wished and at the same time make the experiment under as natural conditions as possible.

Every attempt so far to treat the soil, the seed or the growing crop has failed to give satisfactory results and the only chance appears in being able to raise rust-resisting varieties of wheat.

CHAPTER IV.—Entomological Observations.

Our knowledge of the insect pests common to the provinces is at present very defective. During the past year a beginning has been made in the systematic study of the insects found on the Cawnpore Farm, and the following notes summarise the information that has been collected.

The sugarcane borer (*chilo simplex*) &c.

This borer is not the only one, but that which about here apparently does most damage to sugarcane, maize and juár.

Last year the sugarcane was attacked in the early stage, destroying the young shoots. As the plants grew stronger no further damage was observed and I was unable to find any outward signs of the borer during the rest of the sugarcane's growth, though larvæ were found in the tops at crushing time. This year the young shoots have again been attacked in a similar manner.

Both this year and last attempts have been made to find the eggs of the sugarcane borer. Last year the late Mr. DeNiceville came up on purpose, but so far on sugarcane, maize or juár growing in the farm, we have not been fortunate enough to find any eggs.

I believe that a good deal, if not all, of this injury in the early stages of the sugarcane is due to the sowing of infected cuttings in which the borer is overlooked. It has been noticed when tops are sown that the shoots growing from the terminal bed are the ones affected.

The juár plants appear to be nearly all more or less attacked at some time of their life, but it does not appear to affect their growth and production of grain very much.

I have not found the borer pupating during the cold season, but they appear to remain as larvæ in the cut and uncut juár. In March they began to pupate and in about two weeks the moth appears. Thus, these would be in time to lay eggs and affect the young sugarcane, but as mentioned no eggs have been found. There are apparently two or more generations during summer. The maize plants are attacked when young in some cases killing the plant and in others injuring its growth. The larvæ pupate in the stalk or inside the leaf sheath and the second generation appear to attack the plant higher up, the larvæ entering the stalk a little below the cob and in many cases the cobs were injured by the larvæ eating a passage through the grains along the face of the cob and finally pupating there. There appears no difficulty in transferring these borers from one of these three plants to the other. Pupation takes place again at the end of May and June in time for maize and juar. Some moths kept in captivity have laid some eggs (about 200 eggs were laid by one moth); these will be hatched out and, if possible, reared and the number of generations studied.

Fresh sugarcane is being grown in large cages into which moths will be put, and the plants will be carefully examined to find out where eggs are laid. The young maize and juár will also be carefully watched for eggs from the time they appear above ground.

I have tried placing boards covered with bird lime with lamps to attract the moths at night with the object of catching them, but without success. The best way to treat the young sugarcane appears to be cut off the infected shoots and burn them. Another year I think that cutting off and destroying the terminal bud of tops used as cuttings might be tried. An experiment with pickling might also be made but this would, I think, only be worth doing practically in cases where really very great damage was being done.

A Dipterous Insect.—In the decayed portion of the stem of the sugar cane, maize and juar resulting from the injury of the borer a white larvæ (maggot) about $\frac{1}{4}$ inch long is invariably found. It pupates inside the decayed stems, the pupœ are about $\frac{1}{4}$ inch long of a dull red colour.

The late Mr. DeNiceville appeared to think that these maggots probably destroyed the borer larvæ. I have always found them associated but never seen any ill effects to the borer. They appear to do no damage to the plant only occurring in the decayed portions of plants already injured by the borer.

Cockchafer beetle attacking roots of sugar cane ; sub-family melolonthini.

The grubs and pupæ are found about 6 inches below the surface about the roots of the sugarcane in May and June. The grub is fleshy whitish $\frac{5}{8}$ of an inch long the body of fairly uniform thickness throughout with the usual yellowish orange coloured head, biting jaws and three pairs of legs of the cockchafers. The pupæ are whitish $\frac{3}{8}$ of an inch long. The segments of the abdomen are raised in sharp ridges and the last segment of the body is furnished with two horn-like appendages about $\frac{1}{16}$ inch apart, giving a somewhat square appearance to the tips of the abdomen.

The beetles have not yet appeared.

So far no particular damage has been noticed ; it no doubt aids the withering of the leaves, which often occurs before the rains, and may be the real cause. It is hardly possible to do anything.

Ripersia Sacchari ; Family coccidœ.—Between the leaf sheaths and stem of the sugarcane may be found hidden the pinkish fleshy adult female scales, surrounded by a cottony secretion. They are oval and flattish in shape about $\frac{3}{16}$ inch long and remain stationary. The more active young with distinct legs are easily seen with a magnifying glass. The males are winged and in this family are rarely seen.

The damage, as far as I have noticed, appears trifling, though at other times and in other places this may not perhaps be so. They suck the juices of the cane and should they occur in sufficient numbers to cause serious injury, the only treatment possible would be to remove the sheathing leaves and destroy them, but of course this would be feasible only when it was a question of saving the crop.

Dictyophora pallida ; Family Fulgoridæ.—Last year the sugarcane was covered by a considerable number of sucking bugs. The adult is of a whitish colour and easily recognized by its long upturned snout.

The young are without wings and possess two peculiar feathery-like appendages posteriorly. Their eggs are laid on the leaves in oblong clusters and covered with a woolly down and were taken for those of the sugarcane borer when first seen in April. There appear to be several

generations. No steps were taken to destroy them as no apparent harm resulted from their presence. In Southern India they are reported doing considerable injury. If very bad, spraying with kerosene emulsion would be best.

Beetles on Maize.—About the time the maize cobs were forming large numbers of beetles were found on the plants: these proved to be *Cantharis rouxi* Castella, a dull grey colour (larger) and *Cantharis tenuicollis, Pall.*, a shining green colour, (smaller) Family cantharidœ. They attacked both the stamens and the stigmas. Sitting on the male flower with the head pointing downwards they pulled the anthers off the filaments and ate them. On the female flower they ate through the stigmas but did not eat the part above; where they had eaten through this fell over on the cob or on the ground and the remaining part was left eaten off short.

As these beetles were travelling to and from the male and female flowers I was not quite sure if they were really doing any damage or were perhaps assisting in fertilization. For this reason no steps were taken to destroy them, though I have no doubt a solution of Paris green would have been effective. On examining the cobs when ripe, it was found there were a good many which had undeveloped ovaries in patches about the cobs in an unusual manner, a condition very likely resulting from eating off the stigmas.

Insect Pests on cotton.—In the month of August the plants were attacked by a small borer *Earias Fabia, Stoll,* identified for the first time as attacking cotton, but known as attacking the common "Bhindi" (*Hibiscus Esculentus*) another malvaceœ. There are possibly two generations, the first tunnelling into the young shoots which wither and dry up, the second into the flowers destroying the young bolls (ovaries).

On the first signs of withering, the injured portions of the plant containing the borer were cut off and burnt. The shoots of nearly every plant were attacked, but not many of the bolls. The treatment appeared effective as the pest disappeared, the plants practically suffering no injury.

Oxycarenus lugubris; Family, Lygacidœ.—This insect lives in the open cotton bolls, sucking the oil from the seed and causing the cotton to mat together and become stained. There are several generations. They lay thin eggs on the seed itself or close to it amongst the cotton.

The eggs are whitish at first oblong, minute; about 6 to 8 are laid in a little cluster, as they approach hatching they have a reddish appearance due to the colour of the young insect inside. They hatch out in about 30 hours, the young are reddish in colour with one or two red and white bands seen under magnifying glass. The full grown insect is black about $\frac{2 \text{ to } 3}{16}$ of an inch long, the female being the larger.

They appear as soon as the bolls are formed and last the whole season. They attack both the American and country cotton, the American suffering most.

Dysdercus cingulatus; Family Lygacidœ.—This is another sucking bug, female about $\frac{1}{2}$ inch long, male rather smaller. Colour red with black on wings and 7 to 8 transverse white lines on under surface of body; appeared to be as common on country cotton as on the American. They suck the cotton seeds and the unopened bolls. It is difficult when this and the former are present at the same time on the cotton to estimate the exact damage done by each kind, but Oxycarenus lugubris, being very numerous and living in the bolls has, I think, been the chief cause of any injury this year.

In Dysdercus cingulatus the sexes unite and disunite two or three times and about 30 hours after the female lays from 60 to 75 eggs. The eggs have been found laid on the ground and also loose inside the three

bracts which surround the flower, they are whitish and round to oval in shape.

During the heat of the day the bugs go down on the ground in the shade of the plants. They are also found on the "Bhindi." (*Hibiscus Esculentus*).

Treatment.—For Oxycarenus lugubris, the open bolls were sprayed with a kerosene solution by means of a small hand spray; this killed the bugs but dust collected on the cotton and rather spoilt its colour.

For Dysdercus cingulatus I intended to make traps with cotton soaked in cotton seed oil and Paris green but have been unable to get the poison.

Myllocerus maculosus; *Family, curculisnidæ.*—This is a whitish grey weevil, with black eyes, also a few black dots on the wing cases which are marked with faint parallel raised lines. The female is about $\frac{5}{16}$ of an inch long. The male somewhat smaller. When frightened they drop off the leaf or disappear quickly on the under surface. They feed on the leaves of the cotton plant eating round the leafs edge so as to give it a notched appearance. So far they have not given much trouble except in experiments, where cotton has been grown two years running on the same land. Spraying with Paris green would kill them, but spraying is unsatisfactory during the rains, and at the farm when necessary a boy or two has been put on to hand pick them and drop them into a tin containing a little kerosene and water. They appear as if they might be very troublesome on a cotton farm where the plants were grown on or near the same land every year.

Weevil on juár (name unknown).—This resembles the previous one but it is smaller and brownish in colour, though somewhat lighter on the under surface. It is found on the young rolled leaves of the juár. Damage trifling at present and so far has only just been noticed on the early sown juar.

Mango Pest (Idiocerus niveosparsus); Family Jussidæ.—This is another sucking bug but belongs to the class of leaf hoppers, with long hind legs fitted for leaping. They spring away quickly on being disturbed. These bugs are about $\frac{3}{16}$ inch long, have a broad short triangular head and the body tapers away distinctly to a point.

A noticeable feature is the cast off skins of the insects which may be seen adhering in great numbers to the leaves.

In 1901 this pest occurred in enormous numbers around Cawnpore, just about the time of flowering, clustering on the inflorescence and sucking the juice; much injury was also done by the loss of the sap which escaped from the innumerable punctures made by the insects and dripped down over the leaves and boughs giving them a sticky appearance. The loss was so great that hardly any fruit formed. The size of the mango trees makes it impossible to deal with this pest without a powerful spray pump; even then it would be necessary to attack the bugs in their early stages otherwise their skins become too hard for the insecticide to take effect. The experiment of keeping mango trees within certain limits of size might be tried. By this method though the yield from each fruit tree is less it allows of more trees to the acre, the fruit is more easily picked and insect pests are more easily dealt with.

It is possible that the mango trees might not flourish under this method or at least not yield as heavily as if left to themselves. There is also great danger of fungi gaining entrance to the trees unless great care is taken.

The cost of spraying a mango tree, 15 feet high with kerosene emulsion, would be from three to five annas for one application.

CHAPTER V.—Miscellaneous.

1. *Wheat-breeding.*—Operations were started during the year on the lines indicated in Agricultural Ledger No. 2 of 1901. The work was mainly preliminary, consisting in the training of the staff and the detailed record of the qualities of the large number of races which had been collected from various sources. Crosses were made in considerable numbers, but it will, of course, be some years before any practical results can be expected. The actual work is so detailed that no summary can be given; but it may be mentioned that the qualities now being sought are resistance to drought and to rust, if possible combined in one race.

Workers on the same lines were trained for the Panjáb Agricultural Department, while officers from Bombay and the Central Provinces came to the farm to study the methods adopted.

2. *Trials of drought resisting fodder plants.*—When in Australia in 1900, I enquired from various authorities as to the fodder plants on which the dry regions depend for grazing, in the hope that some suitable plant might be found for clothing ravines in these provinces. The seeds obtained were sown at Cawnpore, and the young plants put out on a piece of poor land at the head of a ravine. The result were as follows :—

Atriplex nummularia, or tall saltbush—

The seed proved to be bad and germination was very defective. Only one plant survived. This variety has often been tried in Saháranpur and Aligarh and always dies off in the wet season.

A. halimoides, or dwarf saltbush—

The seed, obtained from the same source as *Atriplex nummularia*, was very bad and no results were obtained.

A. Semibaccata, or half berried saltbush—

At first this did best of all and seeded freely. In April last the plantation contained a fair stock of vigorous plants, but the great majority were killed off by the heat and drought of May and June.

A. vesicaria—

This grew fairly at first but the plants suffered greatly from heat and drought and very few have survived.

A. leptocarpa—

This also did very fairly until the end of April and seeded freely, but the seeds will not germinate for some reason which I have not discovered. May and June were fatal to most of the plants.

Chenopodium auricomum, or bluebush—

The 1901 sowing failed, but earlier sowings in 1902 have given very promising young plants which are still in pots.

Sorghum halepense, or Johnston grass—

This was highly recommended to me as a persistent deep-rooted grass. On trial at Cawnpore the root development was so great and bore so close a resemblance to *kans*, that I put an abrupt end to the trials. I have since learnt that the grass got into the Saháranpur gardens some years ago and is a very troublesome weed. It is apparently only suitable for the poorest land in places where it cannot extend to cultivation.

Cytisus prolifer—

This was entirely killed off by the heat of May and June, not a single plant surviving.

Paspalum dilatatum—

This was not recommended to me in Australia, but was tried at the instance of a Calcutta Association. For a long time it could not be got to germinate, but a small plot is now growing. The growth is very slow under the conditions prevailing at Cawnpore.

3. *Nitrogen investigations.*—Arrangements have been made in consultation with the Inspector-General of Agriculture and the Agricultural Chemist for a systematic investigation of the losses and gains of nitrogen in the soil at Cawnpore. The gains from rain and canal-water will be determined in the usual way, while loss by drainage will be determined by means of drain-gauges constructed on the model used at Rothamstead. These determinations along with the field experiments indicated in Chapter I will go far to throw light on the obscure question of how the unmanured land of the country retains its productive powers. For a complete study of the question detailed bacteriological examination of the organisms of the soil is essential, but this enormous undertaking will apparently have to stand over for the present as neither the Imperial nor the Provincial Bacteriologist can spare the time required.

4. *Sugar boiling.*—Endeavours have been made during the last few years to improve on the system of sugar manufacture now prevailing in Rohilkhand. Last winter a factory equipped in accordance with our experience was sent on tour through some of the chief centres of the industries. The quality of sugar produced was admittedly superior to the native product, but there was not time for quantitative determinations. Through the kindness of the members of the Bareilly Sugar-boilers' Association competitive trials of the two systems have now been arranged for. The result will be reported next year.

Digitized with financial assistance from

Hemendra Kothari

on 24 February, 2020

APPENDIX No. I :—*Amount of rainfall at the Cawnpore Farm in* 1900-1901 *and* 1901-1902.

Month.	1900-1901.		1901-1902.		Average rainfall of eight years.
	Rainy days.	Rainfall in inches.	Rainy days.	Rainfall in inches.	
June ... 1st half ...	1	·40	...	...	3·57
June ... 2nd half ...	3	1·16	...	...	
July ... 1st half ...	5	2·67	2	4·66	9·60
July ... 2nd half ...	7	2·50	4	2·99	
August ... 1st half ...	6	2·90	8	6·28	13·61
August ... 2nd half ...	7	12·82	7	5·39	
September ... 1st half ...	7	5·12	2	·79	6·23
September ... 2nd half ...	4	·93	3	5·95	
October ... 1st half ...	1	·10	...	...	1·73
October ... 2nd half ...	...	...	...	...	
November, 1st half ...	...	...	...	...	·48
November, 2nd half ...	...	...	...	...	
December ... 1st half ...	3	1·05	...	...	·27
December ... 2nd half ...	2	·76	...	·05	
January ... 1st half ...	3	·77	...	·05	·64
January ... 2nd half ...	...	...	...	...	
February ... 1st half ...	2	·47	...	...	·50
February ... 2nd half ...	2	·92	1	·17	
March ... 1st half ...	1	2·5	...	...	·05
March ... 2nd half ...	...	·06	...	...	
April ... 1st half ...	...	...	...	...	...
April ... 2nd half ...	...	...	...	...	
May ... 1st half ...	...	...	1	·55	·33
May ... 2nd half ...	...	...	1	·15	
	54	32·88	29	27·03	